Keysight U2802A 31-Channel Thermocouple Input Device

KEYSIGHT TECHNOLOGIES

User's Guide

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Notices

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Safety Notices

CAUTION

A **CAUTION** notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a **CAUTION** notice until the indicated conditions are fully understood and met.

WARNING

A WARNING notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

Safety Information

The following general safety precautions must be observed during all phases of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Keysight Technologies assumes no liability for the customer's failure to comply with these requirements.

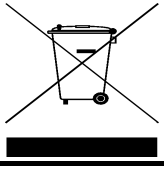
Safety Symbols

The following symbols indicate that precautions must be taken to maintain safe operation of the instrument.

	Direct current
	Alternating current
	Both direct and alternating current
	Three-phase alternating current
	Earth (ground) terminal
	Protective conductor terminal
	Frame or chassis terminal
	Equipotentiality
	On (Supply)

	Off (Supply)
	Equipment protected throughout by double insulation or reinforced insulation
	Caution, risk of electric shock
	Caution, hot surface
	Caution, risk of danger (See note.)
	In position of a bi-stable push control
	Out position of a bi-stable push control

Regulatory Markings

CE ISM 1-A	The CE mark is a registered trademark of the European community. This CE mark shows that the product complies with all the relevant European legal directive.
ICES/NMB-001	ICES/NMB-001 indicates that this ISM device complies with Canadian ICES-001.
C US	The CSA mark is a registered trademark of the Canadian Standards Association. A CSA mark with the indicators "C" and "US" means that the product is certified for both the U.S. and Canadian markets, to the applicable American and Canadian standards.
N10149	The C-tick mark is a registered trademark of the Spectrum Management Agency of Australia. This signifies compliance with the Australian EMC Framework regulations under the terms of the Radio Communications Act of 1992.
	This product complies with the (2002/96/EC) marking equipment. The affixed product label indicates that you must not discard this electrical/electronic product in domestic household waste.

General Safety Information

WARNING

- Do not use the device if it is damaged. Before you use the device, inspect the case. Look for cracks or missing plastic. Do not operate the device around explosive gas, vapor or dust.
- Do not apply more than the rated voltage (as marked on the device) between terminals, or between terminal and external ground.
- Always use the device with the cables provided.
- Observe all markings on the device before connecting to the device.
- Turn off the device and application system power before connecting to the I/O terminals.
- When servicing the device, use only specified replacement parts.
- Do not operate the device with the removable cover removed or loosened.
- Do not connect any cables and terminal block prior to performing self-test process.
- Use only the power adapter supplied by the manufacturer to avoid any unexpected hazards.

CAUTION

- Do not load the input and output terminals above the specified operating limits. Input terminals should not exceed ±10 V with respect to the module ground. Applying excessive voltage or overloading the device will cause irreversible damage to the circuitry.
- Applying excessive voltage or overloading the input terminal will damage the device permanently.
- If the device is used in a manner not specified by the manufacturer, the protection provided by the device may be impaired.
- The U2802A can only be used with U2355A or U2356A DAQs and used with the SCSI cables provided.
- Always use dry cloth to clean the device. Do not use ethyl alcohol or any other volatile liquid to clean the device.
- Do not permit any blockage of the ventilation holes of the device.

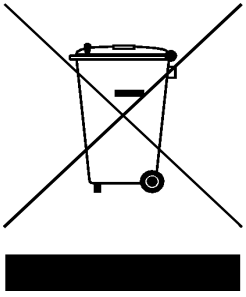
Waste Electrical and Electronic Equipment (WEEE) Directive 2002/96/EC

This instrument complies with the WEEE Directive (2002/96/EC) marking requirement. This affixed product label indicates that you must not discard this electrical/electronic product in domestic household waste.

Product Category:

With reference to the equipment types in the WEEE directive Annex 1, this instrument is classified as a "Monitoring and Control Instrument" product.

The affixed product label is shown as below:



Do not dispose in domestic household waste

To return this unwanted instrument, contact your nearest Keysight office, or visit:

http://www.keysight.com/environment/product

for more information.

Environmental Conditions

The table below shows the general environmental requirements for the product.

Environmental Conditions	Requirements
Temperature	Operating temperature from 0 °C to +55 °C
Humidity	Relative humidity at 50% to 85% RH (Non-condensing)
Altitude	Altitude up to 2000 meters
Storage compliance	–40 °C to +70 °C

In This Guide...

1 Getting Started

This chapter introduces the new Keysight U2802A 31-channel thermocouple input device and provides quick start information. It also provides product outlook, installation configuration and troubleshooting guide.

2 Features and Functions

This chapter contains details of the product features, applications, system overview and theory of operation. From this chapter, you will understand the Keysight U2802A 31-channel thermocouple input system overview and functionality of this device.

3 Pin Configurations and Assignments

This chapter described the Keysight U2802A 31-channel thermocouple input device pin configurations and connector pinout for user's reference.

4 Product Specifications

This chapter specifies the environmental conditions, characteristics, and specifications of the Keysight U2802A 31-channel thermocouple input device. It also covers the system accuracy, typical performance and guidelines to make accurate temperature measurements.

5 Calibration

This chapter contains the calibration information and factory restore calibration procedure for the Keysight U2802A 31-channel thermocouple input device.

Declaration of Conformity (DoC)

The Declaration of Conformity (DoC) for this instrument is available on the Web site. You can search the DoC by its product model or description.

http://www.keysight.com/go/conformity

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This chapter introduces the new Keysight U2802A 31-channel thermocouple input device and provides quick start information. It also provides product outlook, installation configuration and troubleshooting guide.

Introduction to Keysight U2802A 31-Channel Thermocouple Input

The Keysight U2802A 31-channel thermocouple input is a thermocouple input device that functions to convert low input voltage signal (< ±100 mV) from a thermocouple into an output voltage range suitable for data acquisition (DAQ) device (± 10 V).

The Keysight U2802A thermocouple signal conditioner is to be used in conjunction with the U2355A or U2356A model DAQ to enable temperature measurements using thermocouples.

It works as a standalone device attached to a single DAQ. The U2802A thermocouple device is connected to the modular DAQ via SCSI cables. Keysight U2802A accepts eight standard thermocouple types defined in the NIST ITS-90 Thermocouple Database, which are Type B, E, J, K, N, R, S and T.

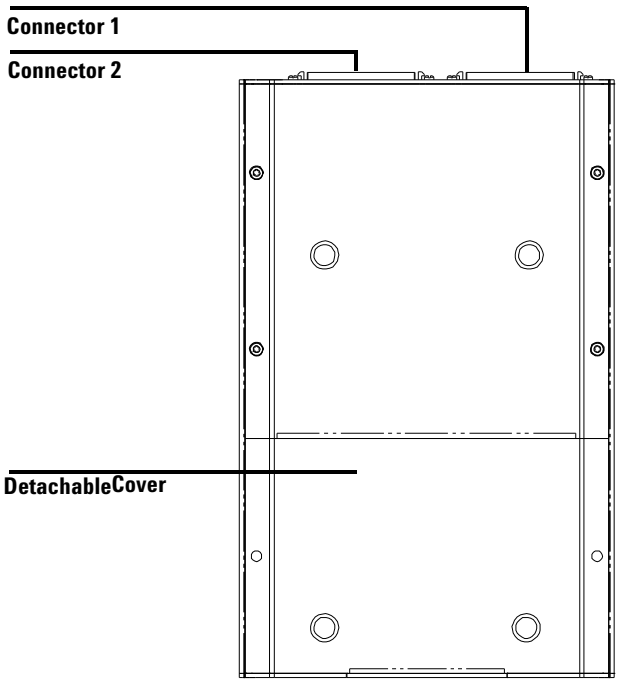
It is ideal for a broad variety of temperature and voltage measurement applications in education, industrial and scientific environments. The U2802A comes with an on-board EEPROM features. Hence, it allows user to store calibration data in volatile memory. Therefore, the U2802A is robust, cost-effective, and user friendly device.

For detailed product specifications, please refer to “General Specifications” on page 40.

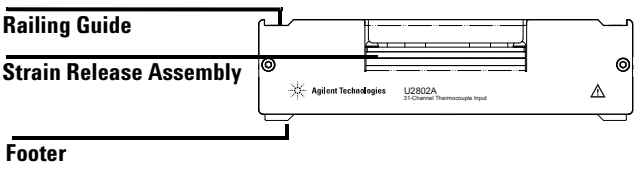
Product Overview

Product Outlook

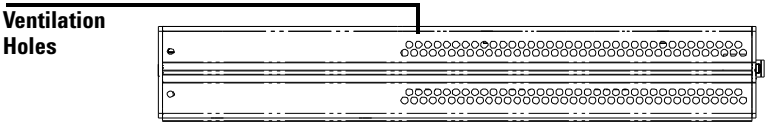
Top View



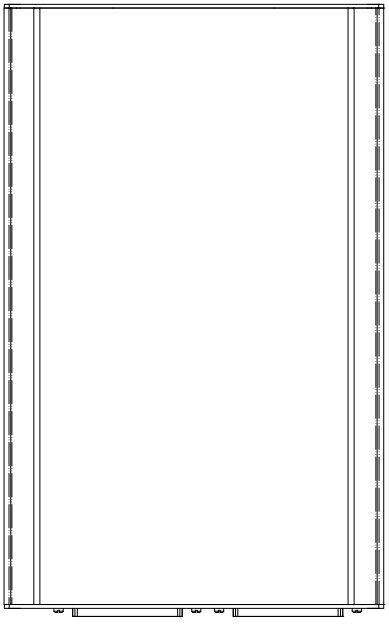
Front View



Side View

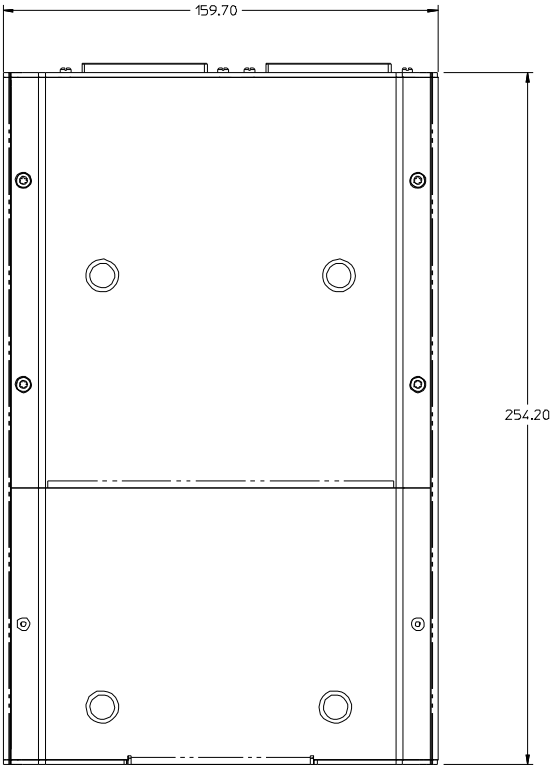


Bottom View

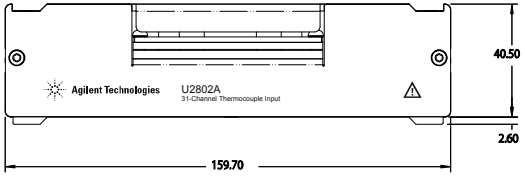


Product Dimensions

Top View



Front View



Standard Purchase Items Checklist

Inspect and verify that you have all the following items upon standard purchase of U2802A 31-channel thermocouple input device. If there are missing items, contact the nearest Keysight Sales Office.

- ✔ Keysight U2802A 31-channel thermocouple input device
- ✔ Power supply splitter
- ✔ Two 68-pin SCSI cables (1 m)
- ✔ One J-type thermocouple
- ✔ Keysight USB Modular Products and Systems Quick Start Guide
- ✔ Keysight USB Modular Products and Systems Product Reference DVD-ROM
- ✔ Keysight Automation-Ready CD-ROM (contains the Keysight IO Libraries Suite)
- ✔ Certificate of Calibration

Installations and Configurations

The U2802A is used in conjunction with the U2355A or U2356A DAQ. If you are using the U2300A Series with the Keysight Measurement Manager, follow the step-by-step instructions as stated in the *Keysight USB Modular Products and Systems Quick Start Guide*.

NOTE You need to install IVI-COM driver before using the U2300A Series with Keysight VEE, LabVIEW or Microsoft Visual Studio.

IVI-COM Drivers

The Keysight IVI-COM drivers simplify instrument control when you are working in a COM-compatible environment. IVI-COM allows you to programmatically control your instrumentation and make measurements while providing a greater degree of instrument interchangeability and code reuse. The Keysight IVI-COM drivers support the use of IntelliSense for even greater ease-of-use within a Microsoft development environment.

The Keysight IVI-COM driver supports all Keysight Series DAQs. The Keysight Firmware Revision: A.2006.10.10 is the minimum revision required for full driver functionality.

An IVI-COM driver can program a particular set of instrument models. It implements an instrument-specific interface tuned to the capabilities of those models. The driver may also implement an IVI class-compliant interface which implements a limited set of functionality common to all instruments of the class. Instrument class-compliant interfaces are defined by the IVI Foundation. The application writer must choose whether to use the instrument-specific interface or the class-compliant interface.

The IVI inherent capabilities, through the IIviDriver interface, are available in both the instrument-specific interface and class-compliant interface. The general programming techniques are also the same.

Choosing Instrument-Specific Interface

With this interface, you have the benefit of full access to the instrument's capabilities. All capabilities in the class-compliant interface are also covered by the instrument-specific interface, but you will find some capabilities in the instrument-specific interface that are not available through the class-compliant interface. You may also see some performance enhancements, as the driver can be tuned to use efficient programming methods for that particular instrument.

Choosing Class-Compliant Interface

By limiting your program to the class-compliant interface, you have the potential advantage of syntactic interchangeability. Hence, another IVI-COM driver (and instrument) which supports the same class could be substituted for the original driver, if the prior IVI-COM driver supports all the capability groups used in the original driver. In this case, the

application will compile, link, and execute without error. The test results, however, may be quite different because different instruments measure and generate signals differently. For more information on class-compliant interfaces and capability groups, visit www.ivifoundation.org.

Using Class-Compliant Interface

Generally, you gain no advantage from using class-compliant interface over using just the instrument-specific interface. However, if you can isolate the usage of the instrument-specific interface, you may see some advantages. Replacing the IVI-COM driver then involves fixing the syntactic incompatibilities in the isolated code.

IVI-COM drivers will be provided to users. The drivers can also be used in a variety of development environments. For more information on IVI, visit www.ivifoundation.org.

Below are the IVI-COM drivers provided:

- ✔ KeysightVEE support through COM mechanism using IVI-COM
- ✔ Visual Basic 6 support through COM mechanism using IVI-COM
- ✔ C++ support through COM mechanism using IVI-COM
- ✔ Visual Basic 7 support through COM Interop mechanism using IVI-COM
- ✔ C# support through COM Interop mechanism using IVI-COM
- ✔ National Instruments LabVIEW support through COM mechanism using IVI-COM

The Keysight firmware update utility is provided to allow users to update firmware on instruments. Update is made available through Keysight Developer Network (ADN) website:

www.keysight.com/find/adn

Programming Environments

An IVI-COM driver works well in a variety of application development environments (ADEs) below:

✔ Keysight VEE

✔ Microsoft® Visual Basic® 6

✔ Visual Studio C++

✔ Visual Basic 7

✔ C#

✔ National Instruments LabVIEW

IVI-COM Driver Installation

1 Verify that your PC meets the minimum system requirements.

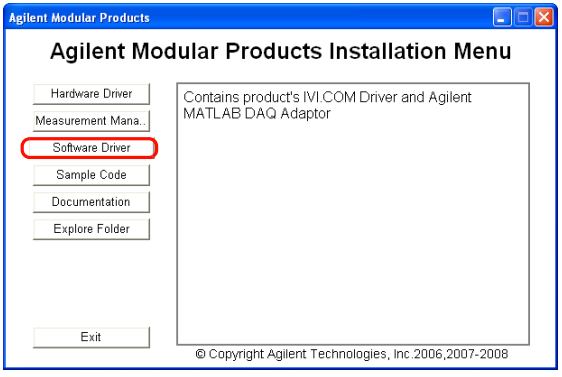
2 Close all other applications on your PC.

3 Insert the *Keysight USB Modular Products and Systems Product Reference DVD-ROM* into the DVD-ROM drive of your PC.

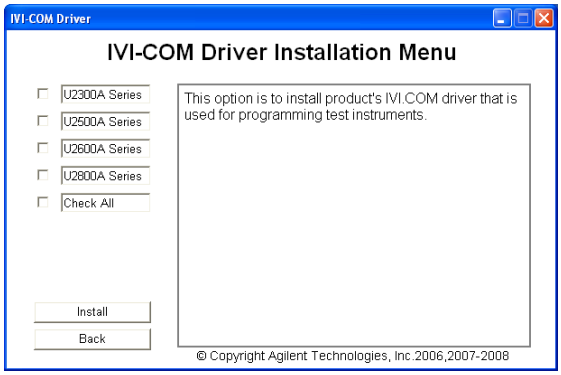
4 Wait for a few seconds for the auto-run window to appear.

5 If the auto-run window does not appear automatically, click **Start > Run**, then type `<drive>:\Autorun.exe`, where `<drive>` is your DVD-ROM drive alphabet.

6 When the auto-run window appears, click **Software Driver** on the Keysight Modular Products Installation Menu.



7 Click **IVI-COM** to open the IVI-COM Driver Installation Menu.

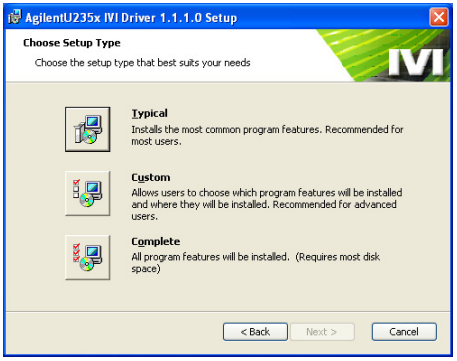


8 Check on the U2300A Series and click **Install** and wait for the Installation Dialog to appear.

9 When the Installation Dialog appears, click **Next** to begin the IVI Driver installation.

10 Read the License Agreement(s). To accept the terms, click on the radio button labeled **I accept the terms in the License Agreement** then click **Next** to continue.

11 When the **Setup Type** dialog box appears, as shown below, clicking **Install** will install all features for your configuration in standard locations on your PC.


AgilentU235x IVI Driver 1.1.1.0 Setup
Choose Setup Type
Choose the setup type that best suits your needs
IVI
Typical
Installs the most common program features. Recommended for most users.
Custom
Allows users to choose which program features will be installed and where they will be installed. Recommended for advanced users.
Complete
All program features will be installed. (Requires most disk space)
< Back
Next >
Cancel

12 If you choose a **Custom** setup, the **Select Features** dialog box will appear.

   a Click on any feature in the list to see the feature's description and space requirement. It is recommended that you install the sample programs if you plan to program with the IVI driver. However, you may omit this recommendation to save space.

   b Select the check box for each feature to be installed. Clear the check box to omit the feature selection.

   c Click **Next**.

1 When the **Ready to Install** dialog box appears, click **Install** to confirm your choices and begin copying files.

2 When the **Complete** dialog box appears, click **Finish**.

2
Features and Functions

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This chapter contains details of the product features, applications, system overview and theory of operation. From this chapter, you will understand the Keysight U2802A 31-channel thermocouple input system overview and functionality of this device.

Features

The U2802A Thermocouple Input conditioning device is complete with the following features:

- ✔ Up to 31 differential input mode, or 31-single ended inputs in voltage input mode. Each of the 31 channels can be configured as either thermocouple or voltage input mode independently.
- ✔ ×97.673 gain setting for thermocouple input mode.
- ✔ Built-in thermistor for cold junction compensation (CJC).
- ✔ Built-in zeroing function to compensate for overall system offset errors due to temperature drift.
- ✔ On-board EEPROM that allows user to restore back original factory calibration data.
- ✔ Open thermocouple detection that allows user to check for any loose or broken thermocouple connection before starting the data acquisition process.
- ✔ Supports thermocouple type J, K, R, S, T, N, E, and B.

Applications

The U2802A Thermocouple Input conditioning device is designed for robust and demanding industrial applications. This product is suitable for a wide range of applications in various fields inclusive of:

✔ Consumer electronics

- Product thermal analysis and characterization
- Environmental testing (Eg: Temperature Cycle)
- Process monitoring (Eg: Oven or solder reflow temperature monitoring)

✔ Education

- Study of electronic cooling properties
- Material properties testing

✔ Container temperature profiling

✔ Appliances testing

System Overview

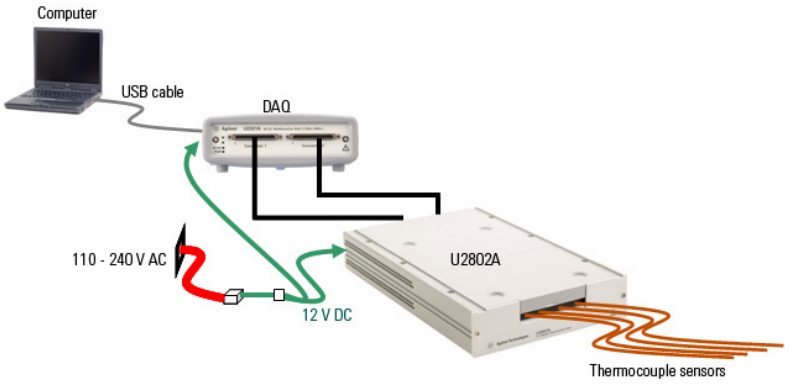

Figure 2-1 System overview of U2802A with DAQ

The U2802A is essentially an amplifier module with a built-in temperature sensor (thermistor). In thermocouple mode, the U2802A input channel is used to amplify a differential voltage signal from a thermocouple (or any low voltage signal source in the range of ±100 mV) by 100 times. The signal is then output as an analog voltage in the ±10 V range into the DAQ for conversion to a digital voltage reading.

The built-in thermistor in the U2802A can be read from Channel AI148 of the U2300A series DAQ. The conversion from voltage to temperature for this thermistor reading is done automatically by the AMM software. This temperature reading will subsequently be used as the Cold Junction Compensation (CJC) reference temperature.

With the correct voltage reading from the thermocouple and the CJC temperature, the AMM software will then proceed to convert the thermocouple voltage reading into a temperature reading, based on the NIST ITS-90 Thermocouple Database. This reading is then corrected for both gain and offset errors due to the U2802A amplifiers using the calibration constants stored in the U2802A EEPROM, which are read by the PC via the DAQ's digital I/O lines.

The U2802A also has a built-in zeroing function, which allows users to zero out the entire system's offset error, thus increasing the overall accuracy of the system.

Theory of Operation

Functionality of the System

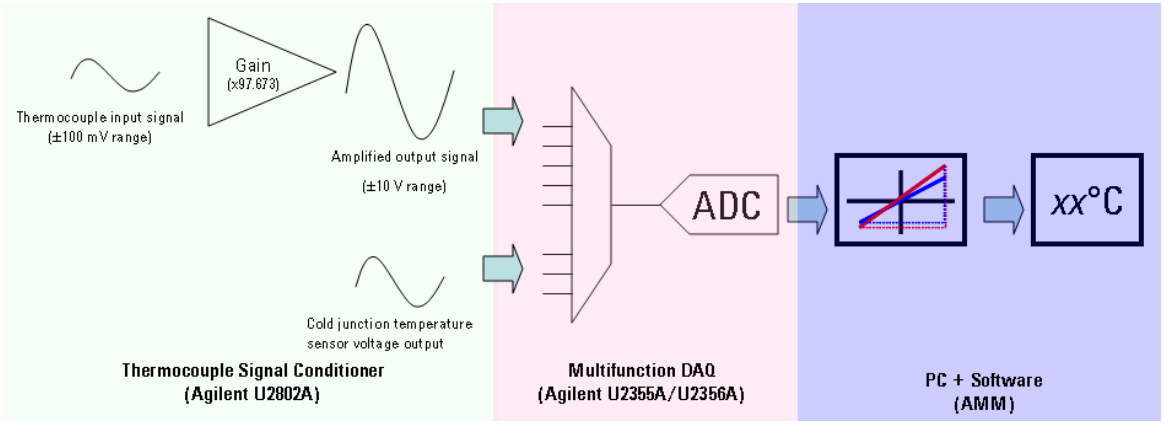

Figure 2-2 System functionality block diagram for U2802A

13 Thermocouple voltage signals are detected at the U2802A thermocouple inputs.

14 Signal is amplified with a gain of 97.673 by the U2802A.

15 The U2355A or U2356A DAQ converts the analog voltage signals to digital voltage readings.

16 The AMM software (or IVI-COM driver) reads the Gain and Offset calibration constants from the U2802A EEPROM via the DAQ DIO lines. The digital voltage readings will be calibrated based on these constants.

17 The AMM software (or IVI-COM driver) converts the calibrated voltage readings to temperature readings using the ITS-90 conversion polynomials.

Functional Block Diagram

The block diagram below in Figure 2-3 illustrates the key functional components of the U2802A.

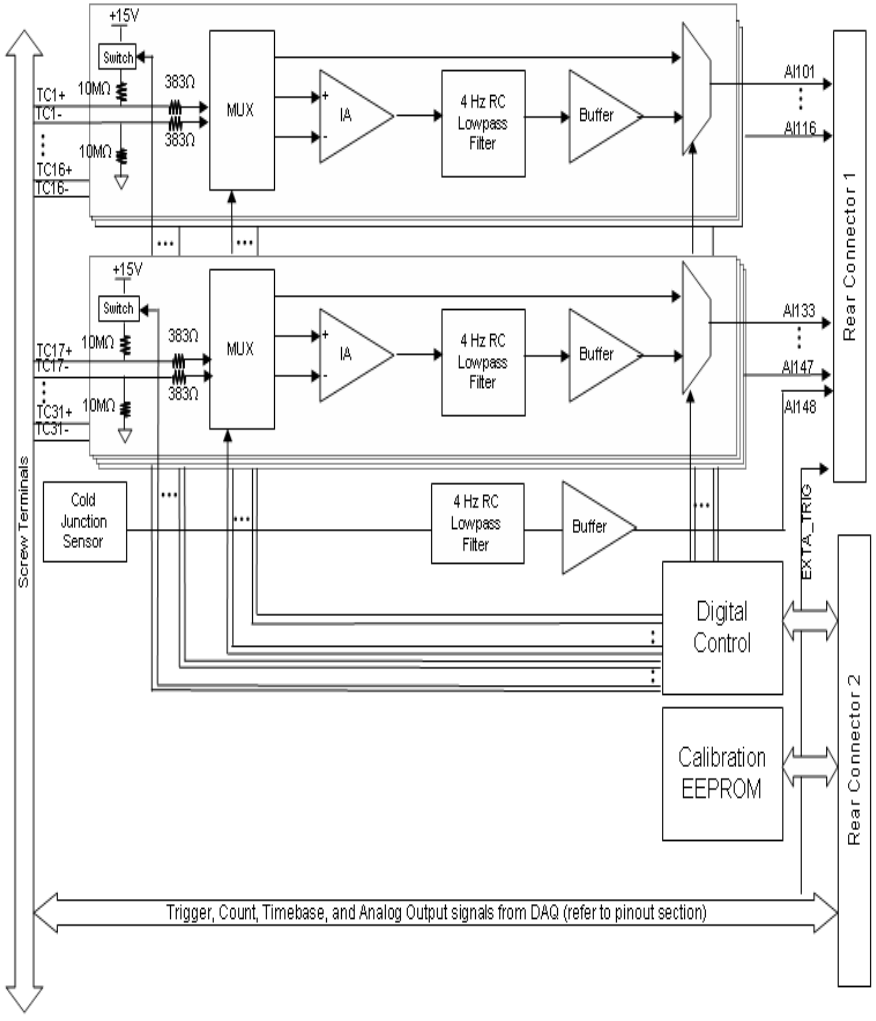

Figure 2-3 Functional block diagram for U2802A

The major functional blocks of the U2802A module are:

- Analog input channel circuitry
- Cold junction sensor
- Digital control logic
- EEPROM

Analog input channel circuitry

The analog circuitry for each channel consists of an instrumentation amplifier with a fixed gain of 97.673, a 4 Hz RC low-pass filter, and an output buffer. The multiplexers at the input and output of each channel allows each channel to be configured for three modes of operation as listed below:

Thermocouple input mode: In thermocouple mode, the thermocouples (or any floating voltage source) should be connected to the TCn+ and TCn– terminals as illustrated in Figure 2-4. All TCn– terminals are internally tied to module ground with a 10 MΩ resistor. The TCn+ and TCn– signals are routed to the differential inputs of the instrumentation amplifier. Differential voltage signals at the TCn+ and TCn– terminals are amplified, filtered and driven out by single-ended output voltage to the corresponding AI channel on Rear Connector 1.

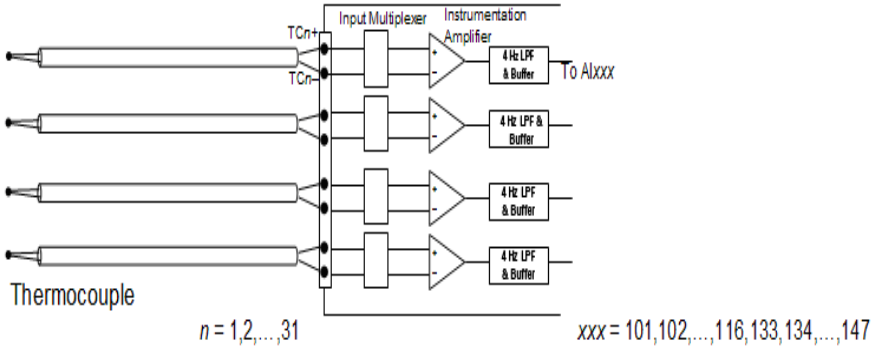

Figure 2-4 Functional block diagram for thermocouple mode in U2802A

Bypass mode: In bypass mode, the TCn+ input is routed directly to the corresponding AI channel on Rear Connector 1. The single-ended signals tied to TCn+ should be referenced to a GND pin, and not to the TCn– input, as it is not directly connected to GND. The signal connection will depend on the type of source used.

For floating signal sources, all input signals are connected to the ground in the U2802A as illustrated in Figure 2-3. However, it is not recommended to tie ground-referenced signal sources in this manner. Any potential differences between the signal source ground and the U2802A ground could potentially induce excessive current to flow through the ground wires causing the wires and module to be damaged.

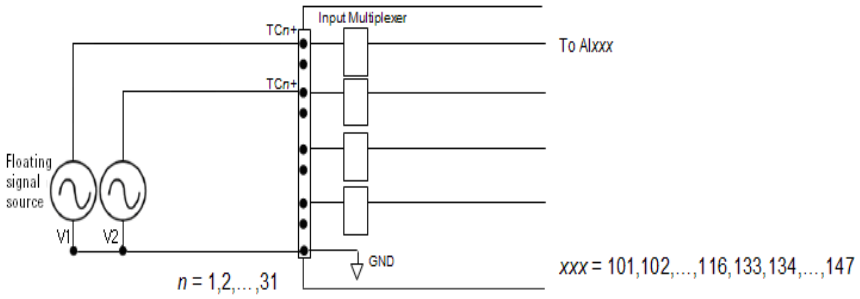

Figure 2-5 Floating signal source configuration in U2802A

For ground-referenced signal sources and differential signal sources, the configuration in Figure 2-6 is recommended. Take note that the corresponding DAQ channel will need to be configured as a DIFF input to enable this type of connection.

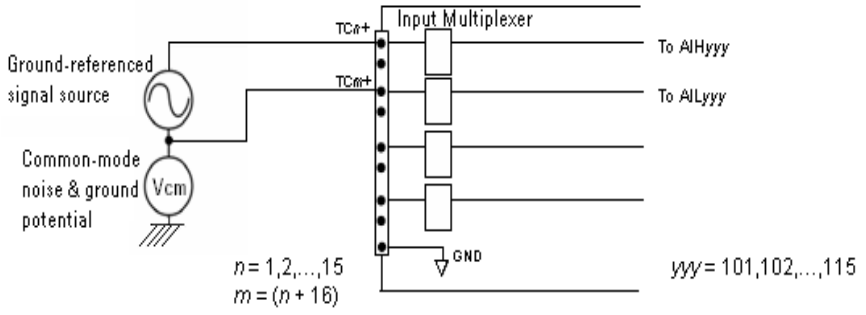

Figure 2-6 Ground-referenced and differential signal sources configuration in U2802A

Zero mode: In zero mode, the positive and negative inputs of the instrumentation amplifier are shorted together. The output of the instrumentation amplifier is driven out to the corresponding AI channel. The voltage measured in this mode corresponds to the offset voltage of the channel. This voltage can be subtracted out of the subsequent thermocouple mode measurements in order to increase the measurement accuracy. Do take note that this mode only works for channels that have been configured to be in the thermocouple mode. Channels configured for bypass mode will not be affected when this mode is selected.

Each channel is equipped with an open thermocouple detection feature, where the 10 MΩ resistor is tied to the +15 V power supply rail. This feature can only be globally enabled or disabled for all channels, regardless of the channel mode setting. When enabled, outputs of the channels are set to thermocouple mode where the inputs are left open-circuited. This causes the positive power supply rail voltage (above +10 V) to be saturated up, indicating that the channel either has a broken thermocouple or the thermocouple is not connected. For channels set to bypass mode, channels with an open-circuited input will also be saturated to the positive supply rail voltage.

For bypass mode channels that are connected to valid voltage sources, the 10 MΩ pull-up resistor will cause additional current to flow through the voltage source. However, this additional current measurement is small and negligible for low impedance voltage sources.

For thermocouple mode channels connected to valid thermocouples, the presence of the pull-up resistor introduces approximately 0.75 μA of current through the thermocouple wires. This current introduces additional errors when using thermocouples with high resistances, and the measurement accuracy could be affected.

Cold junction sensor

A thermistor (RT1) is placed in between the screw terminals to measure the temperature of the thermocouple junction for CJC. The output voltage from the sensor is fed through a 4 Hz RC low-pass filter and buffered to the AI148 pin on Rear Connector 1. The conversion from voltage to temperature is done automatically by the AMM software.

Digital control

The digital control circuit consists of registers that controls the mode of each channel and the open-thermocouple detect feature. The registers are addressed and clocked via the digital I/O pins on Rear Connector 2. This will be handled automatically by the AMM software.

EEPROM

The gain and offset calibration factors for each channel are stored in the EEPROM during factory calibration and will be retrieved prior to taking measurements. The EEPROM is tied to the digital I/O pins on Rear Connector 2. The communication between the EEPROM and host PC is automatically handled by the AMM software. In addition to the calibration factors, the EEPROM stores the module ID, serial number, date of calibration, which can also be retrieved before measurements are taken.

Open Thermocouple Detection

The U2802A provides a built-in 10 MΩ resistor on each TC+ terminal, which is pulled up to the internal +15 V power supply rail. This resistor can be enabled or disabled via the digital I/O pins on Rear Connector 2. When enabled, this 10 MΩ pull-up resistor and the 10 MΩ pull-down biasing resistor will cause the output from any unconnected thermocouple input channels to saturate to the maximum output voltage. The U2355A and U2356A devices can read this saturated channel and detect that a particular channel has an open thermocouple input.

Trigger, Counter, External Timebase, and Analog Output

The U2802A provides a direct access to the analog and digital trigger lines, counter channels, external timebase input, and analog output channels from the U2355A and U2356A devices. These lines are routed directly from the Rear Connector 1 and 2 to the J60 screw terminal connector. Please refer to pin description for **Connector J60** on **page 35**. Precautions should be taken when driving high slew rate and frequency clocks into the Counter and External Timebase lines to avoid excessive noise coupling into other analog and digital lines. If excessive coupling or crosstalk is observed, clock output drive strengths and slew rates should be lowered to reduce coupling while still maintaining proper digital function.

3
Pin Configurations and Assignments

Pin Configurations 30
    Pin Assignments 30
    Pin Description 31
Connector Pinout 36

This chapter described the Keysight U2802A 31-channel thermocouple input device pin configurations and connector pinout for user's reference.

Pin Configurations

Pin Assignments

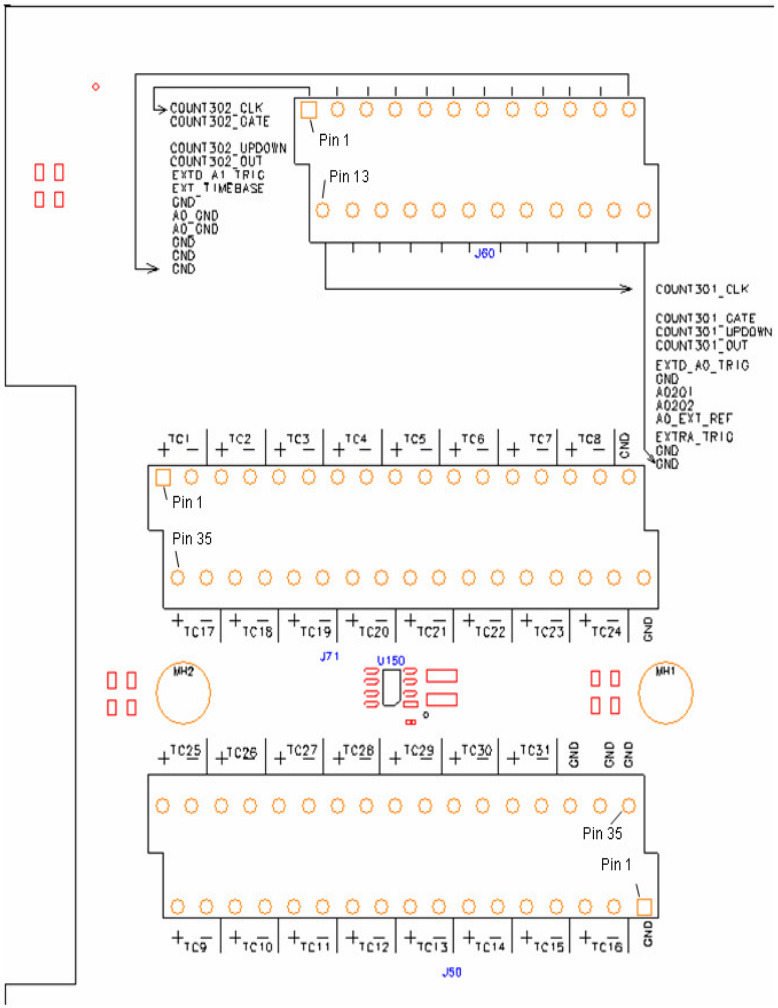

Figure 3-7 U2802A pin assignment

Pin Description

Connector J71

Pin	Pin name	Description
1	TC1+	In thermocouple mode, TCx+ and TCx– are the thermocouple differential input. In voltage mode, single ended input at TCx+ and GND. TCx– is not connected.
2	TC1–	
3	TC2+	TC input or voltage input (See TC1+/– description)
4	TC2–	
5	TC3+	TC input or voltage input (See TC1+/– description)
6	TC3–	
7	TC4+	TC input or voltage input (See TC1+/– description)
8	TC4–	
9	TC5+	TC input or voltage input (See TC1+/– description)
10	TC5–	
11	TC6+	TC input or voltage input (See TC1+/– description)
12	TC6–	
13	TC7+	TC input or voltage input (See TC1+/– description)
14	TC7–	
15	TC8+	TC input or voltage input (See TC1+/– description)
16	TC8–	
17	GND	Module Ground
18	TC17+	TC input or voltage input (See TC1+/– description)
19	TC17–	
20	TC18+	TC input or voltage input (See TC1+/– description)
21	TC18–	
22	TC19+	TC input or voltage input (See TC1+/– description)
23	TC19–	
24	TC20+	TC input or voltage input (See TC1+/– description)
25	TC20–	
26	TC21+	TC input or voltage input (See TC1+/– description)
27	TC21–	

28	TC22+	TC input or voltage input (See TC1+/– description)
29	TC22–	
30	TC23+	TC input or voltage input (See TC1+/– description)
31	TC23–	
32	TC24+	TC input or voltage input (See TC1+/– description)
33	TC24–	
34	GND	Module Ground

Connector J50

Pin	Pin name	Description
1	GND	Module Ground
2	TC16–	TC input or voltage input (See TC1+/– description)
3	TC16+	
4	TC15–	TC input or voltage input (See TC1+/– description)
5	TC15+	
6	TC14–	TC input or voltage input (See TC1+/– description)
7	TC14+	
8	TC13–	TC input or voltage input (See TC1+/– description)
9	TC13+	
10	TC12–	TC input or voltage input (See TC1+/– description)
11	TC12+	
12	TC11–	TC input or voltage input (See TC1+/– description)
13	TC11+	
14	TC10–	TC input or voltage input (See TC1+/– description)
15	TC10+	
16	TC9–	TC input or voltage input (See TC1+/– description)
17	TC9+	
18	GND	Module Ground
19	GND	Module Ground
20	GND	Module Ground
21	TC31–	TC input or voltage input (See TC1+/– description)
22	TC31+	
23	TC30–	TC input or voltage input (See TC1+/– description)
24	TC30+	
25	TC29–	TC input or voltage input (See TC1+/– description)
26	TC29+	
27	TC28–	TC input or voltage input (See TC1+/– description)
28	TC28+	
29	TC27–	TC input or voltage input (See TC1+/– description)
30	TC27+	

31	TC26–	TC input or voltage input (See TC1+/– description)
32	TC26+	
33	TC25–	TC input or voltage input (See TC1+/– description)
34	TC25+	

Connector J60

Pin	Pin name	Description
1	COUNT302_CLK	Directly connected to DAQ[1]
2	COUNT302_GATE	Directly connected to DAQ[1]
3	COUNT302_UPDOWN	Directly connected to DAQ[1]
4	COUNT302_OUT	Directly connected to DAQ[1]
5	EXTD_AI_TRIG	Directly connected to DAQ[1]
6	EXT_TIMEBASE	Directly connected to DAQ[1]
7	GND	Module Ground
8	AO_GND	Directly connected to DAQ[1]
9	AO_GND	Directly connected to DAQ[1]
10	GND	Module Ground
11	GND	Module Ground
12	GND	Module Ground
13	COUNT301_CLK	Directly connected to DAQ[1]
14	COUNT301_GATE	Directly connected to DAQ[1]
15	COUNT301_UPDOWN	Directly connected to DAQ[1]
16	COUNT301_OUT	Directly connected to DAQ[1]
17	EXTD_AO_TRIG	Directly connected to DAQ[1]
18	GND	Module Ground
19	AO201	Directly connected to DAQ[1]
20	AO202	Directly connected to DAQ[1]
21	AO_EXT_REF	Directly connected to DAQ[1]
22	EXTA_TRIG	Directly connected to DAQ[1]
23	GND	Module Ground
24	GND	Module Ground

1. Refer to the *U2300A Series USB Multifunction Data Acquisition Devices User's Guide* for connectivity

Connector Pinout

Rear panel pinout for Connector 1

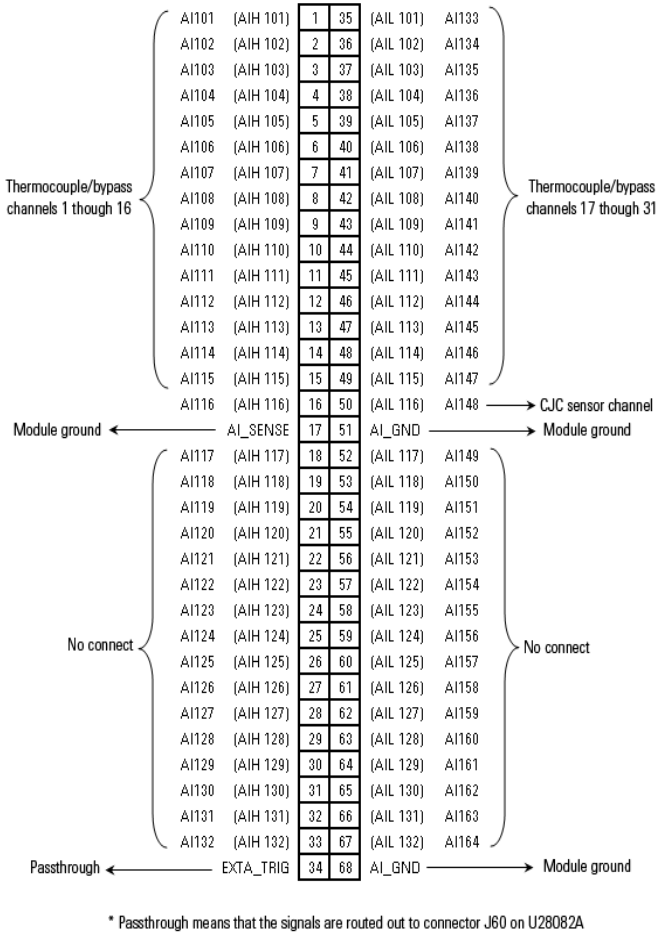
Thermocouple/bypass channels 1 though 16
Thermocouple/bypass channels 17 though 31
AI101 (AIH 101) 1 35 (AIL 101) AI133
AI102 (AIH 102) 2 36 (AIL 102) AI134
AI103 (AIH 103) 3 37 (AIL 103) AI135
AI104 (AIH 104) 4 38 (AIL 104) AI136
AI105 (AIH 105) 5 39 (AIL 105) AI137
AI106 (AIH 106) 6 40 (AIL 106) AI138
AI107 (AIH 107) 7 41 (AIL 107) AI139
AI108 (AIH 108) 8 42 (AIL 108) AI140
AI109 (AIH 109) 9 43 (AIL 109) AI141
AI110 (AIH 110) 10 44 (AIL 110) AI142
AI111 (AIH 111) 11 45 (AIL 111) AI143
AI112 (AIH 112) 12 46 (AIL 112) AI144
AI113 (AIH 113) 13 47 (AIL 113) AI145
AI114 (AIH 114) 14 48 (AIL 114) AI146
AI115 (AIH 115) 15 49 (AIL 115) AI147
AI116 (AIH 116) 16 50 (AIL 116) AI148
CJC sensor channel
Module ground
AI_SENSE 17 51 AI_GND
Module ground
No connect
No connect
AI117 (AIH 117) 18 52 (AIL 117) AI149
AI118 (AIH 118) 19 53 (AIL 118) AI150
AI119 (AIH 119) 20 54 (AIL 119) AI151
AI120 (AIH 120) 21 55 (AIL 120) AI152
AI121 (AIH 121) 22 56 (AIL 121) AI153
AI122 (AIH 122) 23 57 (AIL 122) AI154
AI123 (AIH 123) 24 58 (AIL 123) AI155
AI124 (AIH 124) 25 59 (AIL 124) AI156
AI125 (AIH 125) 26 60 (AIL 125) AI157
AI126 (AIH 126) 27 61 (AIL 126) AI158
AI127 (AIH 127) 28 62 (AIL 127) AI159
AI128 (AIH 128) 29 63 (AIL 128) AI160
AI129 (AIH 129) 30 64 (AIL 129) AI161
AI130 (AIH 130) 31 65 (AIL 130) AI162
AI131 (AIH 131) 32 66 (AIL 131) AI163
AI132 (AIH 132) 33 67 (AIL 132) AI164
Passthrough
EXTA_TRIG 34 68 AI_GND
Module ground
* Passthrough means that the signals are routed out to connector J60 on U28082A

Figure 3-8 Connector 1 pin assignment for U2355A and U2356A

Rear panel pinout for Connector 2

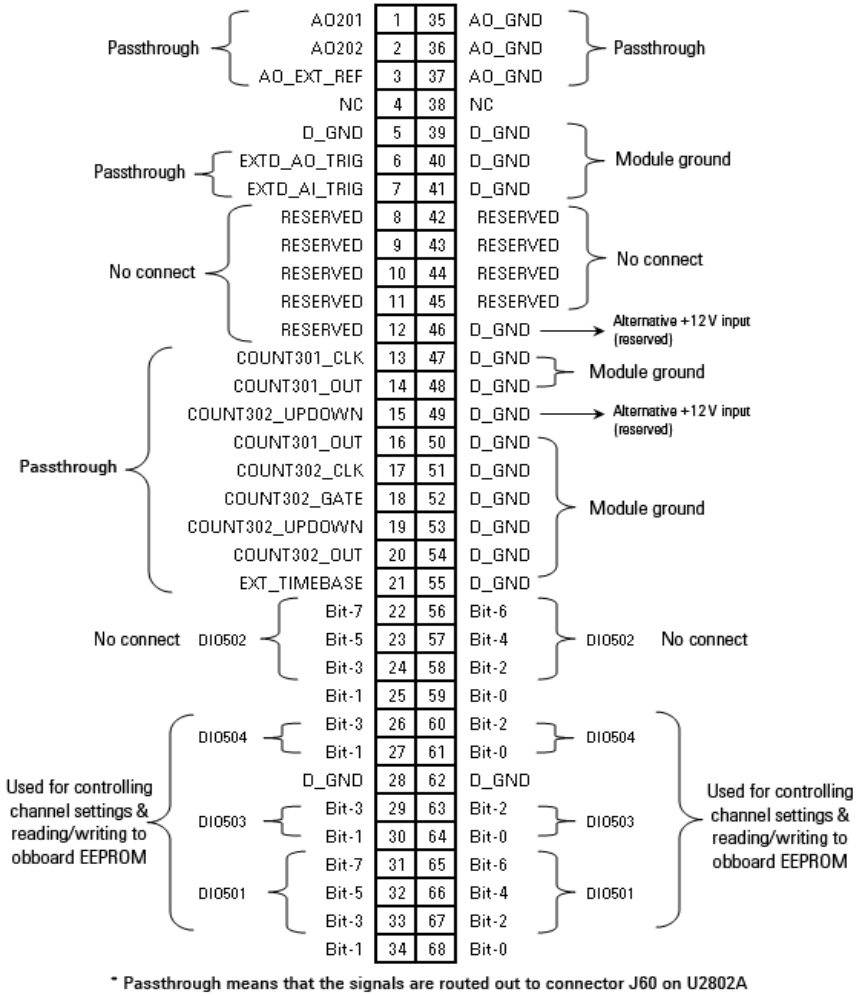

Figure 3-9 Connector 2 pin assignment for U2355A and U2356A

4
Product Specifications

General Specifications 40
Product Characteristics 41
System Accuracy Specifications 43
Calculating System Accuracy 46
System Typical Performance 49
Making Accurate Temperature Measurements 51

This chapter specifies the environmental conditions, characteristics, and specifications of the Keysight U2802A 31-channel thermocouple input device. It also covers the system accuracy, typical performance and guidelines to make accurate temperature measurements.

General Specifications

POWER CONSUMPTION

±12 VDC, 750 mA maximum

OPERATING ENVIRONMENT

- Operating temperature from 0 °C to 55 °C
- Relative humidity at 50% to 85% RH (non-condensing)
- Altitude up to 2000 meters

STORAGE COMPLIANCE

–40 °C to 70 °C

SAFETY COMPLIANCE

Certified with IEC 61010-1:2001/EN 61010-1:2001 (2nd Edition)

EMC COMPLIANCE

- IEC 61326-1:2002 / EN 61326-1:1997+A1:1998+A2:2001+A3:2003
- CISPR 11:1990/EN55011:1990 – Group 1, Class A
- CANADA: ICES-001: 2004
- Australia/New Zealand: AS/NZS CISPR11:2004

SHOCK & VIBRATION

Tested to IEC/EN 60068-2

IO CONNECTOR

- 2 x 68-pin female SCSI connector
- 2 x 34-pin screw terminal block
- 1 x 24 pin screw terminal block

DIMENSIONS (WxDxH)

159.7 mm x 254.2 mm x 40.5 mm

WEIGHT

1.036 KG

WARRANTY

Please refer to http://www.keysight.com/go/warranty_terms

- Three years for the product
- Three months for the product's standard accessories, unless otherwise specified

Please take note that for the product, the warranty does not cover:

- Damage from contamination
- Normal wear and tear of mechanical components
- Manuals

Product Characteristics

GENERAL CHARACTERISTICS	
Number of channels	31 differential and 1 CJC
Input voltage range for voltage mode	±10 V (signal + common mode)
Input voltage (thermocouple mode)	±100 mV
Sampling rate for thermocouple mode	10 kSa/s total for all channels
Sampling rate for overall module	500 kSa/s
Thermocouple types	J, K, R, S, T, N, E and B
INPUT SPECIFICATIONS	
Accuracy (thermocouple mode) Overall gain error Overall offset error Nonlinearity	 0.06% (23 °C ± 5 °C) 15 µV (without zeroing) (23 °C ± 5 °C) 6 µV (with zeroing) < 0.005% of Full Scale Range
System noise (rms) Gain (x1) Gain (x100)	 100 µVrms 5 µVrms
Common mode rejection ratio (60 Hz) Voltage mode Thermocouple mode	 > 60 dB > 80 dB
Cold junction accuracy	±1.0 °C typical (23 °C ± 5°C) ±1.5 °C typical (0 °C to 18 °C, 28 °C to 55 °C)
INPUT CHARACTERISTICS	
Bandwidth (voltage mode)	> 500 kHz
Bandwidth (thermocouple mode)	4.0 Hz

Overvoltage protection*	**TC Mode†** • Common mode: ±17 V (TC+ and TC– with respect to GND) • Differential mode: ±7 V (Differential voltage between TC+ and TC–) **Bypass mode** • ±20 V (TC+ input with respect to GND) **Power Off Mode** • ±11 V (TC+, TC– input with respect to GND)
Input impedance	> 1 GΩ
Input bias current	±2.5 nA max
Input offset current	±1.5 nA max
Gain drift	60 ppm / °C max
Offset drift	1 µV / °C max
Filter cutoff frequency (–3 dB) (thermocouple mode)	4.0 Hz
Filter type (thermocouple mode)	Low Pass RC Filter
OTHER FEATURES	
Recommended warm up time	30 minutes

* The overvoltage protection levels specified above indicate the maximum voltage each input pin can tolerate without resulting in any damages. However, prolonged exposure to these levels may affect device safety and reliability. Hence, it should be avoided where possible.

† On the channels configured for thermocouple mode, the TC+ and TC– pins can tolerate up to ±17 V of differential voltage for a few minutes. However, exceeding ±100 mV voltage range on these channels can cause additional current to be drawn from the device's power supply regulators, which may damage the device if multiple channels are overdriven for prolonged periods. This applies to the case where a voltage source is tied across the TC_n+ and TC_n– pin. Voltage sources greater than ±100 mV should be tied to TC_n+ and GND (floating source), or TC_n+ and TC_{n+1}+ (grounded source), and have the channels set for bypass mode. Refer to Figure 2-5 on page 24.

System Accuracy Specifications

The Keysight U2802A thermocouple input measurement accuracy with the U2355A and U2356A is as shown in Table 4-1, Table 4-2, and Table 4-3.

NOTE

- Assume a ±1 °C error in the CJ measurement due to sensor error and temperature gradient error in the accuracy numbers in Table 4-1, Table 4-2, and Table 4-3 below.
- Table 4-1, Table 4-2, and Table 4-3 are derived from the U2802A and DAQ input accuracy specifications without including the thermocouple error. Refer to "Calculating System Accuracy" on page 46 for calculation methodology.

Thermocouple Measurements Accuracy (U2355A, U2356A @ 23 °C ± 5°C)							
T/C Type	ITS-90 Temperature Range (°C)		Optimum Measurement Range(°C)		Without averaging (± °C)	50 points averaging (± °C)	500 points averaging (± °C)
	Low	High	Low	High			
B	0	1820	1100	1820	1.9	1.2	1.0
			400	1100	4.4	2.5	2.0
E	–270	1000	–150	1000	1.7	1.6	1.6
			–200	–150	2.4	2.3	2.3
J	–210	1200	–150	1200	1.6	1.5	1.5
			–210	–150	2.7	2.6	2.5
K	–270	1372	–100	1200	1.5	1.4	1.4
			–200	–100	2.7	2.6	2.6
N	–270	1300	–100	1300	1.5	1.3	1.3
			–200	–100	3.0	2.7	2.6
R	–50	1768	300	1760	2.0	1.4	1.3
			–50	300	5.0	3.1	2.6
S	–50	1768	400	1760	2.1	1.6	1.4
			–50	400	4.5	2.8	2.4
T	–270	400	–100	400	1.5	1.4	1.4
			–200	–100	2.7	2.5	2.5

Table 4-1 U2802A measurement accuracy with U2355A or U2356A, at 23 °C ± 5 °C, with different number of averaging points.

Thermocouple Measurements Accuracy (U2355A @ 0 °C to 18 °C and 28 °C to 45 °C)							
T/C Type	ITS-90 Temperature Range (°C)		Optimum Measurement Range(°C)		Without averaging (± °C)	50 points averaging (± °C)	500 points averaging (± °C)
	Low	High	Low	High			
B	0	1820	1100	1820	3.4	2.4	2.2
			400	1100	7.5	3.6	2.2
E	–270	1000	–150	1000	2.7	2.6	2.5
			–200	–150	3.8	3.6	3.6
J	–210	1200	–150	1200	2.5	2.4	2.4
			–210	–150	4.2	4.0	3.9
K	–270	1372	–100	1200	2.9	2.8	2.8
			–200	–100	4.3	4.0	3.9
N	–270	1300	–100	1300	2.6	2.5	2.5
			–200	–100	4.9	4.2	4.0
R	–50	1768	300	1760	3.8	3.1	3.0
			–50	300	8.5	4.6	3.3
S	–50	1768	400	1760	4.2	3.4	3.2
			–50	400	7.7	4.2	3.1
T	–270	400	–100	400	2.4	2.2	2.2
			–200	–100	4.3	4.0	3.9

Table 4-2 U2802A measurement accuracy with U2355A, at 0 to 18 °C and 28 to 45 °C, with different number of averaging points.

Thermocouple Measurements Accuracy (U2356A @ 0 °C to 18 °C and 28 °C to 45 °C)							
T/C Type	ITS-90 Temperature Range (°C)		Optimum Measurement Range(°C)		Without averaging (± °C)	50 points averaging (± °C)	500 points averaging (± °C)
	Low	High	Low	High			
B	0	1820	1100	1820	6.1	3.1	2.4
			400	1100	14.4	6.3	2.7
E	–270	1000	–150	1000	3.0	2.6	2.6
			–200	–150	4.2	3.7	3.6
J	–210	1200	–150	1200	2.9	2.5	2.5
			–210	–150	4.9	4.1	4.0
K	–270	1372	–100	1200	3.3	2.9	2.9
			–200	–100	5.3	4.2	4.0
N	–270	1300	–100	1300	3.4	2.7	2.6
			–200	–100	6.8	4.6	4.1
R	–50	1768	300	1760	6.2	3.7	3.2
			–50	300	15.7	7.2	3.8
S	–50	1768	400	1760	6.4	4.0	3.4
			–50	400	14.2	6.6	3.4
T	–270	400	–100	400	3.0	2.4	2.2
			–200	–100	5.3	4.2	3.9

Table 4-3 U2802A measurement accuracy with U2356A, at 0 to 18 °C and 28 to 45 °C, with different number of averaging points.

Calculating System Accuracy

The overall measurement system comprises of three major components:

1. DAQ (U2355A or U2356A)
2. Signal Conditioner (U2802A), which includes CJ Sensor error
3. Sensor (Thermocouples)

Errors introduced by each of the above components has to be accounted for when calculating the total system accuracy. Since errors from each component are not correlated with each other, the total system error will be the root-sum-square (RSS) of all the errors:

$$E_{TOTAL}^2 = E_{DAQ}^2 + E_{SIG\_COND}^2 + E_{THERMOCOUPLE}^2$$

Example:

Assume the following conditions:

- DAQ: Keysight U2355A
- Signal Conditioning: Keysight U2802A
- Ambient temperature: 23 °C
- Thermocouple type: J-type, standard limits of error
- Temperature to measure: 600 °C

Assume the following error specifications:

- U2355A: Gain error = 0.02% of reading
- Offset error = 1 mV
- U2802A gain = 97.673
- Gain error = 0.06% of reading
- Offset error = 15 µV (with respect to input)
- Zeroing error = 6 µV (with respect to input)
- CJ measurement accuracy = 1 °C
- Thermocouple = greater than 2.2 °C or 0.75% error
- Noise error has been omitted to simplify the example

With zeroing, the offset errors from the DAQ and the U2802A can be removed, and replaced with the zeroing error.

Based on the ITS-90 Thermocouple table, a J-type thermocouple will output 33.102 mV at 600 °C, and changes at a rate of approximately 59 µV/°C. This corresponds to (33.102 mV × 97.673) or 3.2332 V at the input of the DAQ.

Hence, E_{DAQ}, E_{SIG_COND}, and $E_{ZEROING}$ are calculated as follows:

- E_{DAQ}
  = 0.02% × 33.102 mV
  = 6.62 µV
  = 6.62 µV ÷ 59 µV/°C
  = 0.112 °C

- E_{SIG_COND}
  = (0.06% × 33.102 mV) ÷ 59 µV/ °C
  = 0.337 °C

- $E_{ZEROING}$
  = 6 µV ÷ 59 µV/°C
  = 0.102 °C

Next, the cold junction sensor error is calculated.

At 23 °C, a J-type thermocouple output voltage changes at a rate of 52 µV/ °C. Thus, the CJ sensor error of 1 °C at 23 °C corresponds to 52uV/ °C × 1°C = 52 µV.

At 600 °C,

- E_{CJC}
  = 52 µV ÷ 59 µV/°C
  = 0.88 °C

Therefore,

$$E_{THERMOCOUPLE} = 0.75\% \times 600\ °C = 4.5\ °C$$

Using the above individual component errors, the total measurement system accuracy is calculated as below.

System accuracy without thermocouple sensor error:

$$E_{TOTAL} = SQRT(E_{DAQ}^2 + E_{SIG\_COND}^2 + E_{ZEROING}^2 + E_{CJC}^2) = 0.95\ °C$$

System accuracy with thermocouple sensor error:

$$E_{TOTAL} = SQRT(E_{DAQ}^2 + E_{SIG\_COND}^2 + E_{ZEROING}^2 + E_{CJC}^2 + E_{THERMOCOUPLE}^2) = 4.6\ °C$$

System Typical Performance

Thermoelectric Characteristics

The thermoelectric characteristics for various thermocouple types is shown in Figure 4-10.

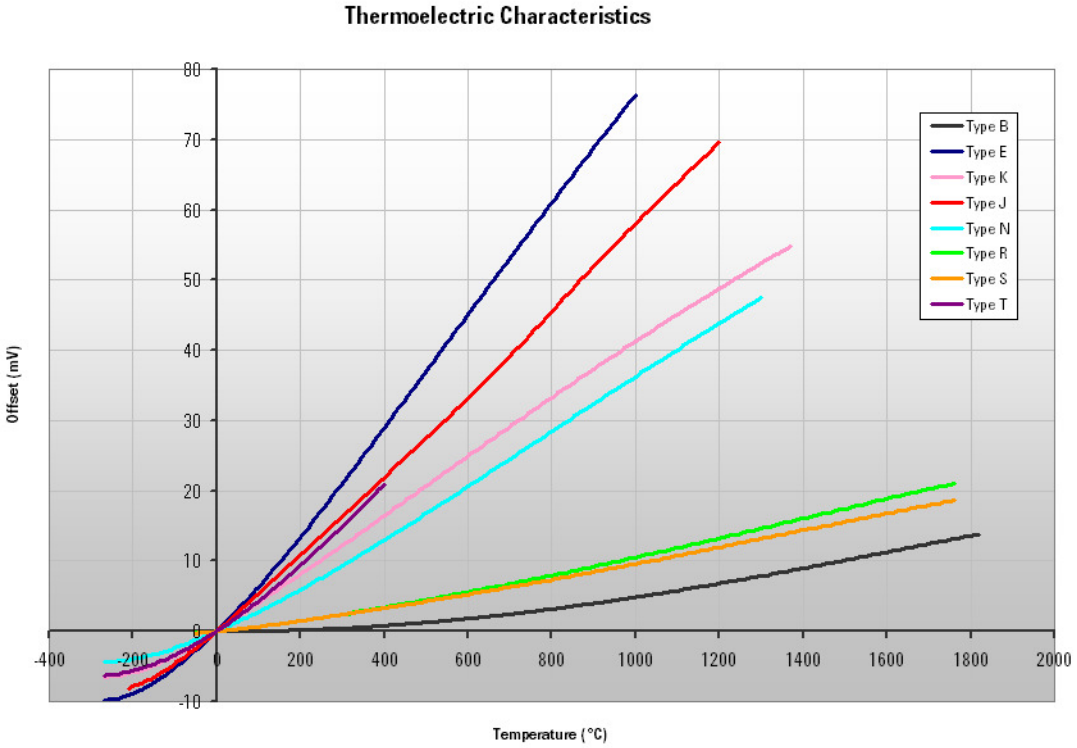

Figure 4-10 Thermoelectric characteristics for various thermocouple types

Typical Error vs. Measurement Performance

The U2802A measurement error with U2355A or U2356A at 23 °C ± 5 °C is shown in Figure 4-11.

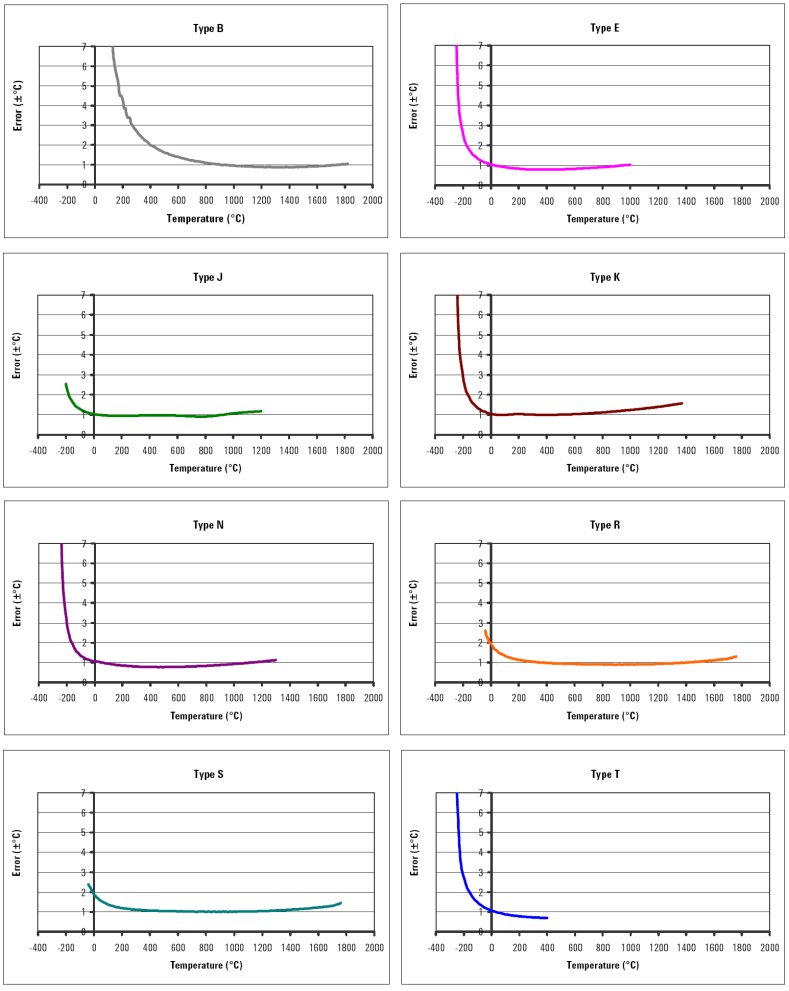

Figure 4-11 U2802A measurement accuracy plot for various thermocouples type

NOTE Assume a ±1 °C error in the CJ measurement due to sensor error and temperature gradient error in the accuracy numbers in Figure 4-2.

Making Accurate Temperature Measurements

Thermocouple measurement accuracy is very sensitive to cold junction sensor errors and temperature gradients across the terminals. Keep the module away from any heat sources and drafts to minimize any variation between channels.

The channels located closest to the center near the reference thermistor will have the best accuracy. It is important to use channels that are physically close together on the screw terminals when taking relative measurements. Channels that are closest together will have the best agreement.

5
Calibration

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This chapter contains the calibration information and factory restore calibration procedure for the Keysight U2802A 31-channel thermocouple input device.

Calibration

Calibration Information

The Keysight U2802A is factory calibrated and the calibration constants are stored in the EEPROM. During initial setup, the calibration constants are read from the EEPROM before any measurements are taken.

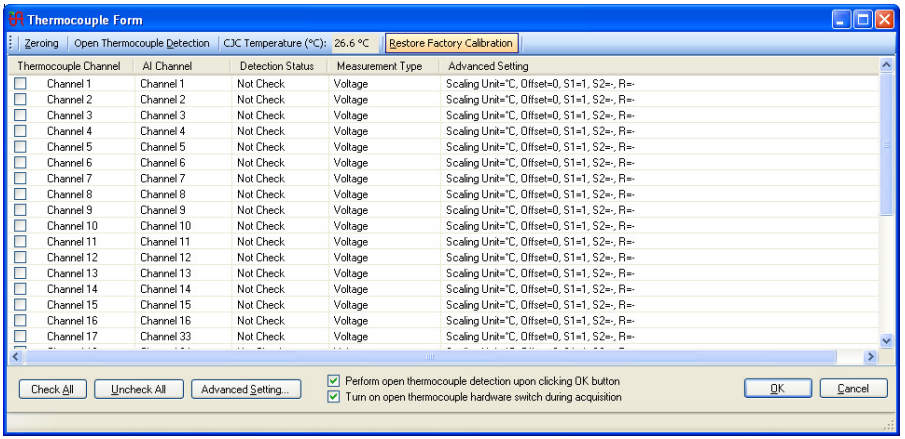
Zeroing Function

The Keysight U2802A thermocouple input device operating in thermocouple mode can be set to zero mode, where the differential inputs of each channel are shorted together. This zeroing function is used to measure the total system offset errors due to initial offset error, temperature drift error, and long term drift error from the DAQ (U2355A or U2356A) and the U2802A. This measurement can then be subtracted from subsequent measurements in order to remove the system offset error.

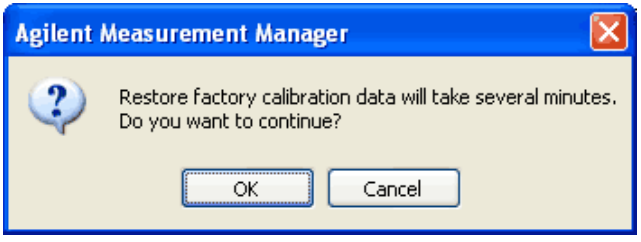
Restore Factory Calibration

The Restore Factory Calibration function in the Keysight U2802A is used to restore calibration data from user's settings to factory original settings. To perform factory restore calibration, follow the step-by-step instructions shown below:

1 Click **Restore Factory Calibration** in the thermocouple form.


Thermocouple Form
Zeroing
Open Thermocouple Detection
CJC Temperature (°C): 26.6 °C
Restore Factory Calibration
Thermocouple Channel
AI Channel
Detection Status
Measurement Type
Advanced Setting
Channel 1 Channel 1 Not Check Voltage Scaling Unit='C, Offset=0, S1=1, S2=-, R=-
Channel 2 Channel 2 Not Check Voltage Scaling Unit='C, Offset=0, S1=1, S2=-, R=-
Channel 3 Channel 3 Not Check Voltage Scaling Unit='C, Offset=0, S1=1, S2=-, R=-
Channel 4 Channel 4 Not Check Voltage Scaling Unit='C, Offset=0, S1=1, S2=-, R=-
Channel 5 Channel 5 Not Check Voltage Scaling Unit='C, Offset=0, S1=1, S2=-, R=-
Channel 6 Channel 6 Not Check Voltage Scaling Unit='C, Offset=0, S1=1, S2=-, R=-
Channel 7 Channel 7 Not Check Voltage Scaling Unit='C, Offset=0, S1=1, S2=-, R=-
Channel 8 Channel 8 Not Check Voltage Scaling Unit='C, Offset=0, S1=1, S2=-, R=-
Channel 9 Channel 9 Not Check Voltage Scaling Unit='C, Offset=0, S1=1, S2=-, R=-
Channel 10 Channel 10 Not Check Voltage Scaling Unit='C, Offset=0, S1=1, S2=-, R=-
Channel 11 Channel 11 Not Check Voltage Scaling Unit='C, Offset=0, S1=1, S2=-, R=-
Channel 12 Channel 12 Not Check Voltage Scaling Unit='C, Offset=0, S1=1, S2=-, R=-
Channel 13 Channel 13 Not Check Voltage Scaling Unit='C, Offset=0, S1=1, S2=-, R=-
Channel 14 Channel 14 Not Check Voltage Scaling Unit='C, Offset=0, S1=1, S2=-, R=-
Channel 15 Channel 15 Not Check Voltage Scaling Unit='C, Offset=0, S1=1, S2=-, R=-
Channel 16 Channel 16 Not Check Voltage Scaling Unit='C, Offset=0, S1=1, S2=-, R=-
Channel 17 Channel 33 Not Check Voltage Scaling Unit='C, Offset=0, S1=1, S2=-, R=-
Check All
Uncheck All
Advanced Setting...
Perform open thermocouple detection upon clicking OK button
Turn on open thermocouple hardware switch during acquisition
OK
Cancel

2 A dialog box will appear as shown below.



3 Click **OK to** start the factory restore calibration process. Click **Cancel** to not perform the restore factory calibration process.

5 Calibration

www.keysight.com

Contact us

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Korea:
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www.keysight.com/find/assist

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